

## Problems to be solved with the Gamma Spectrum Generator

1. The measurement setup is similar to the default configuration “NaI,  $L \times D = 1 \text{ in} \times 2 \text{ in}$  (default)”. You are going to calibrate it using the 1 MBq  $^{60}\text{Co}$  and 1 MBq  $^{137}\text{Cs}$  reference gamma sources. Approximately, how many statistical counts can you expect within 100 s in the corresponding gamma-spectra? Make the evaluations with and without backscattered photon contribution.
2. You have to measure the 10 MBq  $^{152}\text{Eu}$  source with NaI (3"×3") scintillation detector in the measurement setup similar to the default configuration “NaI,  $L \times D = 3 \text{ in} \times 3 \text{ in}$  (default)”. In your disposal there are three lead filters – 1 mm, 3 mm and 5 mm thick. Find the right combinations of the filters, which would make the measurement possible, assuming that your electronics can cope only with input count rates below 20 kcps (kilo counts per second). Check if the same electronics and filters will allow you to perform the measurement in the configuration “HPGe, coaxial, p-type, rel. eff. 150% (default)”.
3. What is the relative efficiency of the HPGe detector with crystal length – 30 mm, crystal diameter – 50 mm, rear contact length – 20 mm, rear contact diameter – 10 mm, inactive Ge – 1.5 mm, cap thickness – 1 mm Al, and crystal to cap distance – 5 mm? What crystal length doubles the detector relative efficiency?
4. The 1 g natural uranium sample ( $^{234}\text{U} - 0.000055 \text{ g}$ ,  $^{235}\text{U} - 0.0072 \text{ g}$ ,  $^{238}\text{U} - 0.992745 \text{ g}$ ) was measured twice on the same NaI (3"×3") scintillation spectrometer (configuration “NaI,  $L \times D = 3 \text{ in} \times 3 \text{ in}$  (default)”). The first and the second measurements were performed for 100000 s respectively 10 days and 1 year after the uranium separation. What are the relative contributions of  $^{235}\text{U}$  and  $^{238}\text{U}$  to the gamma-spectrum measured in both cases? When modeling the spectra, use 1 mm Pb filter to imitate the self-attenuation properties of the sample.
5. Based on the gamma-spectrometric examination of a source, the presence of  $^{60}\text{Co}$  with activity 100 kBq was revealed. Which of the default GSG measurement configurations are suitable for detecting an additional presence of 50 Bq of  $^{241}\text{Am}$  in the same source by performing a 1000 s long measurement?

### **Problems to be solved with the EasyMonteCarlo module**

1. Calculate the gamma dose and flux rates with respective buildup factors for the 1 GBq  $^{60}\text{Co}$  source and  $10\text{ cm} \times 25\text{ cm} \times 25\text{ cm}$  (thickness  $\times$  height  $\times$  width) Pb shield. Source to shield surface distance is 5 cm, detector to shield surface distance is 50 cm.
2. Calculate the gamma dose rate at 10 cm distance from the shielded 1 Ci  $^{241}\text{Am}$  point source. The iron shield has dimensions  $5\text{ mm} \times 50\text{ cm} \times 50\text{ cm}$  (thickness  $\times$  height  $\times$  width) and positioned in between source and detector. Perform calculations with the default (100 keV) and 10 keV gamma-ray energy thresholds. Explain the results obtained.
3. Calculate the gamma dose rates and buildup factors at 1 m distance from an unshielded 1 Ci  $^{152}\text{Eu}$  source. Consider two source geometries: a) point source, and b) uniform distribution in the iron sphere with diameter 5 cm. Explain differences in the build factor values by modeling photon spectral distributions in both cases.
4. Calculate the neutron dose rate and dose buildup factor at 1 m distance from the 1 Ci  $^{252}\text{Cf}$  neutron source. Consider two different shields – 20 cm paraffin and 20 cm lead. Compare dose rate values, buildup factors and contributions of thermal, epithermal and fast neutrons to the full dose rate in both cases. Explain the results obtained.
5. Calculate the neutron dose rate at 1 m distance from a point 14 MeV neutron source emitting  $10^{10}$  neutrons per second. Consider cases of: a) unshielded source, and b) shielded with 10 cm lead source.